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of stimuli *Paramecium* responds with the same motor reaction, in greater or less intensity. The direction of motion after a stimulus is determined by the structure of the animal's body and has no relation to the localization of the stimulus. *Paramecia* are not directly attracted by any agent; they collect in the regions of certain conditions merely in virtue of the fact that these conditions cause no motor reactions, while the surrounding fluid causes a motor reaction that results in random movements, which must (through the laws of chance) eventually bring the animal into a region where these motors cease.

Phototaxis of Daphnia. C. B. DAVENPORT and F. T. LEWIS.

THE problem is to determine the dependence of the degree of phototactic sensitiveness upon preceding conditions of illumination. Other conditions being similar, do *Daphnia* reared in the dark respond to a fainter illumination than those reared in the light? Special apparatus afforded a quantitative answer to this question. *Daphnia* reared in half-darkness moved, on the average, nearly three times as far toward a light of about minimal intensity as did *Daphnia* reared in the light. We may conclude: Those individuals reared in the dark have become attuned to a lower intensity than those reared in the light.

The minimum intensity inducing phototaxis was, in the more sensitive *Daphnia*, 0.002 candle power at a distance of 3.5 meters, or $\frac{0.002}{3.5^2} = 0.00016$ meter candles.

The phototropic sensitiveness of *Daphnia* is quite equal to the phototropic sensitiveness of the most sensitive seedlings.

Early Development of Pennaria Tiarella. CHAS. W. HARGITT.

THE egg of *Pennaria* is of relatively large size and heavily yolk-laden. In color it is of a light orange or pinkish hue. It is

of ectodermal origin and grows by an active absorption of other ovarian cells. The egg is discharged almost immediately upon the liberation of the medusa, which takes place during the evening from seven to ten o'clock. Fertilization occurs very soon after the egg is discharged, or possibly in some cases before, since in many specimens the medusæ are never liberated, and the eggs seem to be discharged with difficulty and not infrequently exhibit segmentation phases while yet within the bell of the medusa. But so far as I have been able to note, the sperms always gain access to the egg from the outside.

The extrusion of the polar globules is only rarely to be noted, but occurs in an altogether normal way. Segmentation begins usually within fifteen minutes of the access of the spermatozoon. The first cleavage is usually into fairly normal two-celled forms, but seldom exactly in the same way, perhaps no two eggs exhibiting the same cleavage features. This is peculiarly the case in all the later phases. It is absolutely indeterminate and remarkably irregular and erratic. So much so was this that during the first series of observations the whole lot were discarded, as probably for some unknown reason abnormal or pathological. A second series taken the next night behaved in the same way, and while still thought to be somewhat abnormal were followed through to the completion of the irregular cleavage, and were found the following morning to have become perfectly normal planulæ.

That they were genuine cleavage phenomena was conclusively proved by sections of the various stages and the demonstration of mitotic figures in all phases of growth and decline.

Somewhat similar though incomparably less marked phenomena had been noted long ago by Wilson in the development of *Renilla*, and by Metschnikoff in *Rathkea* and

Oceania, and, incidentally, by Bunting, in *Hydractinia*. The most nearly comparable observations, so far as I have been able to discover, are those recently reported by Andrews in *Hydra*.

This work was begun at the Marine Biological Laboratory in 1897, continued during 1898, and is still in progress. It is hoped that a fuller account, with definite illustrations, may soon appear.

Grafting Experiments upon Hydromedusæ.
CHAS. W. HARGITT.

IN course of previous work upon regeneration among the Hydromedusæ, the problem of grafting was forcibly impressed upon me, and during the summer of 1898, at the Marine Biological Laboratory, was undertaken and followed up during nearly two months, and with results as briefly outlined below.

It was undertaken to show the practicability of uniting sections of different individuals, different species and even genera.

The first work undertaken was upon Hydroids, chiefly Tubularians, *e. g.*, species of *Eudendrium*, *Pennaria*, *Parypha*, *Clava*, with only one series of experiments upon a Campanularian. The latter was for some reason almost wholly negative in results. In all the former the results were unusually successful, no less than 10% responding within the limits indicated. To merely summarize:

1. No difficulty was found in securing perfect union between segments of the same species in from twelve to twenty-four hours. A delicate sheath of perisarc overlapping the proximal ends was first secreted, and this was followed by organic union of the coenosarc of the hydroid. The grafting was equally successful whether made by oral, aboral or alternating contact of the segments. Abundant heteromorphism was secured along with the other results. 2. It was equally easy to secure union of

male and female specimens of the same species. 3. If the distinctness of Agassiz's species of *Eudendrium dispar* and *ramosum* is to be maintained—a fact which has seemed to me doubtful—then there was secured a ready grafting of different species. 4. In no case was I able to secure successful grafting between different genera. This was tried repeatedly with several, but in each case with negative results.

The second problem undertaken was upon the medusæ. The most accessible form was *Gonionemus vertens*, and the results obtained were on this form alone. Grafting was made possible only by the expedient of paralyzing the specimens by emargination of the entire bell, thus removing the coordinating centers. This done, there was no more difficulty in securing perfect union of different portions of the body than with the hydroid forms. It mattered little from what portion of the body taken, or in what relation placed, perfect union was usually secured in from 24 to 48 hours. Two medusæ grafted orally recovered nervous activity, and even exhibited a definite coördination, the double medusa acting as one.

The Life-History of Dicyema. WILLIAM
MORTON WHEELER.

A STUDY of the Dicyemidæ (*Dicyema coluber*, n. sp.; *Dicyemennea Whitmanii*, n. sp., and *Dicyemodeca sceptrum*, n. gen. et n. sp.), parasitic in the kidneys of the West Coast *Octopus* (*O. punctatus*), was undertaken with a view to answering the following questions concerning the life-history of these animals: 1. What are the relations of the nematogenic and rhombogenic individuals to each other? 2. What is the meaning of the so-called infusoriform embryo? 3. What is the meaning of the infusorigen? An examination of the parasites of one hundred *Octopus* of different ages led to the conclusion that the Dicyemidæ first reproduce as nematogens for several generations, but that